sPHENIX Calorimeter Electronics Overview

sPHENIX Calorimeter Electronics Review

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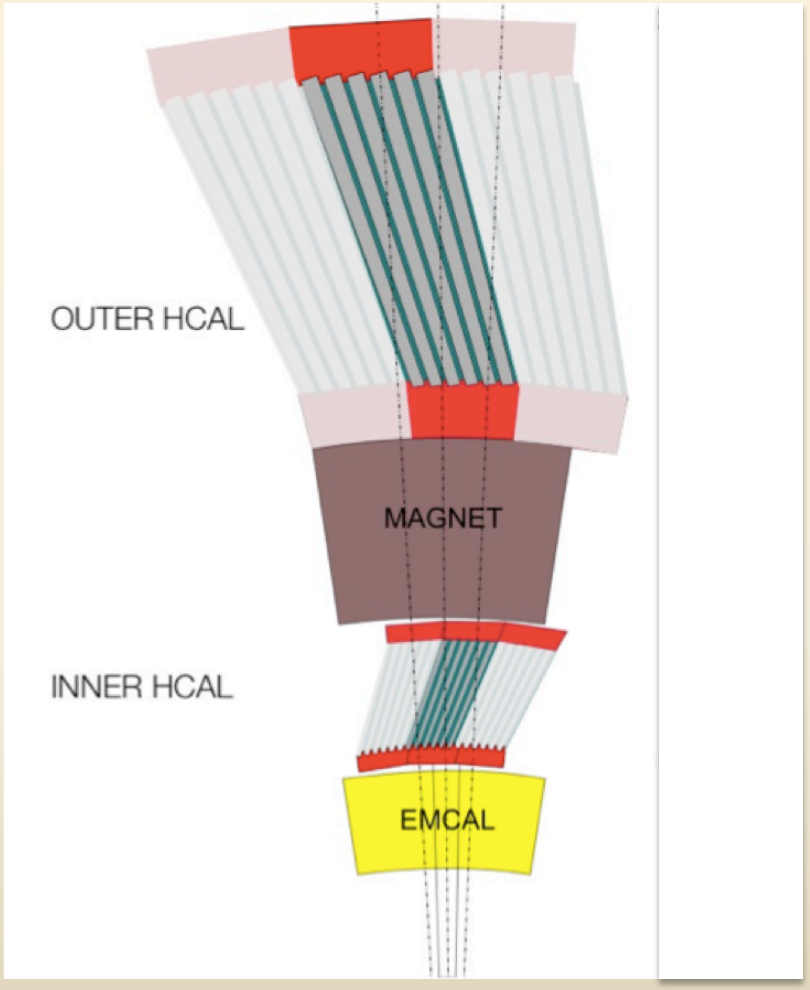
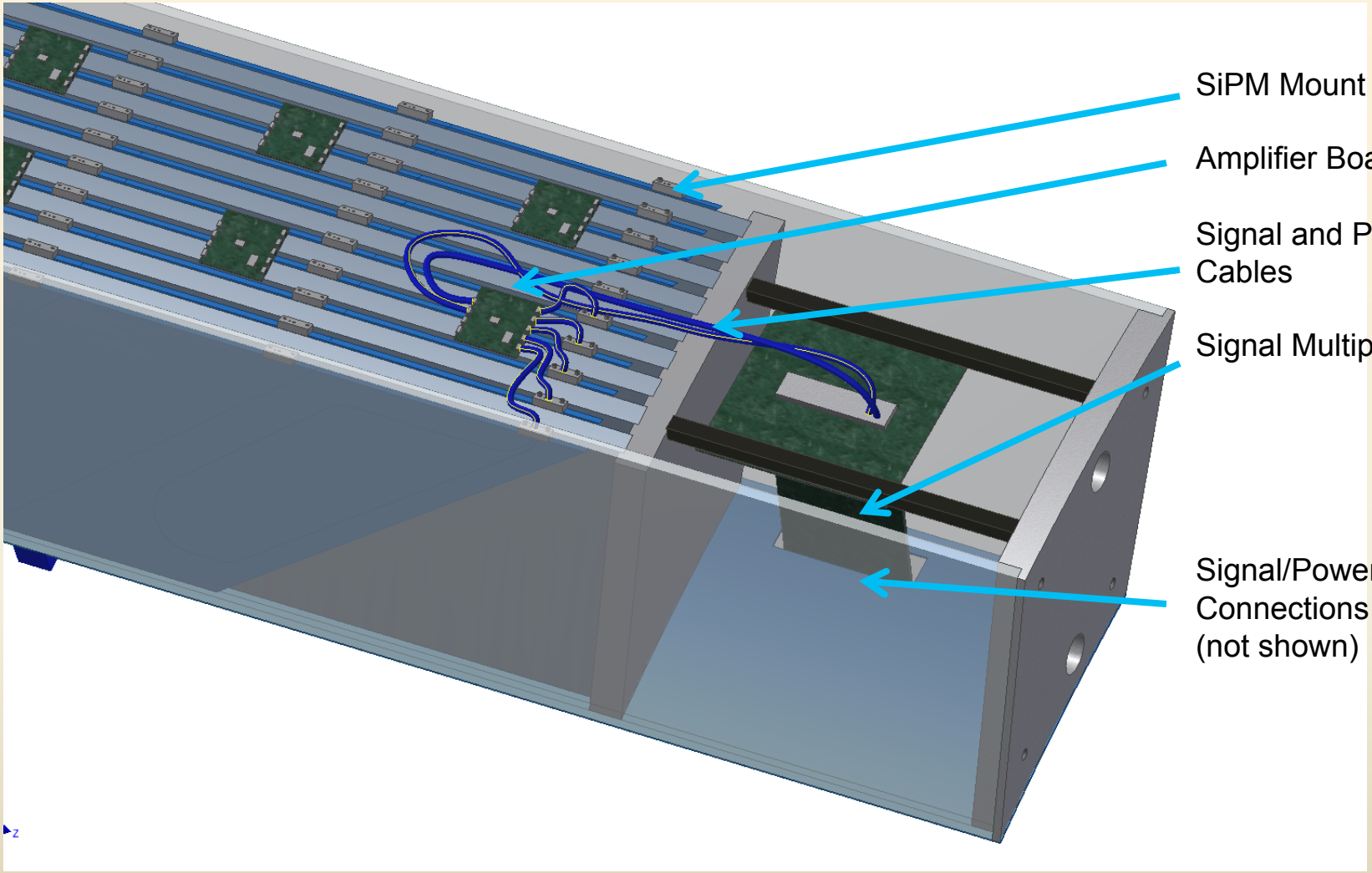
Calorimeter Specifications

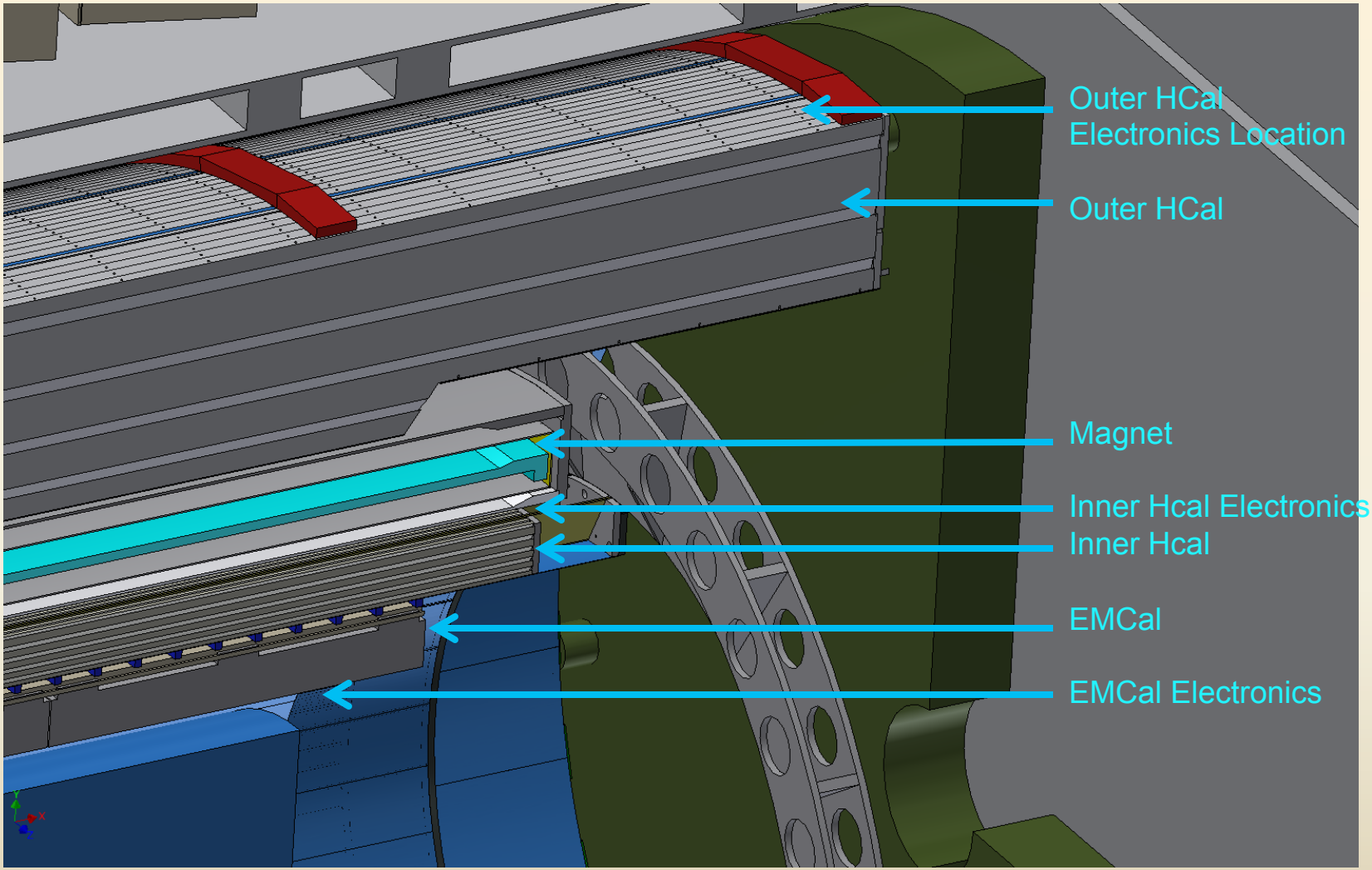
- EMCal: ~18X_0, ~1λ_I
  - Tungsten powder in epoxy with scintillating fibers embedded
  - Readout using SiPMs
- Inner HCal: ~1λ_I
  - Stainless steel absorber
  - Scintillating tiles with wavelength shifting fibers
  - Readout with SiPMs
- Magnet: ~1λ_I
- Inner HCal: ~4λ_I
  - Steel absorber
  - Scintillating tiles with wavelength shifting fibers
  - Readout with SiPMs



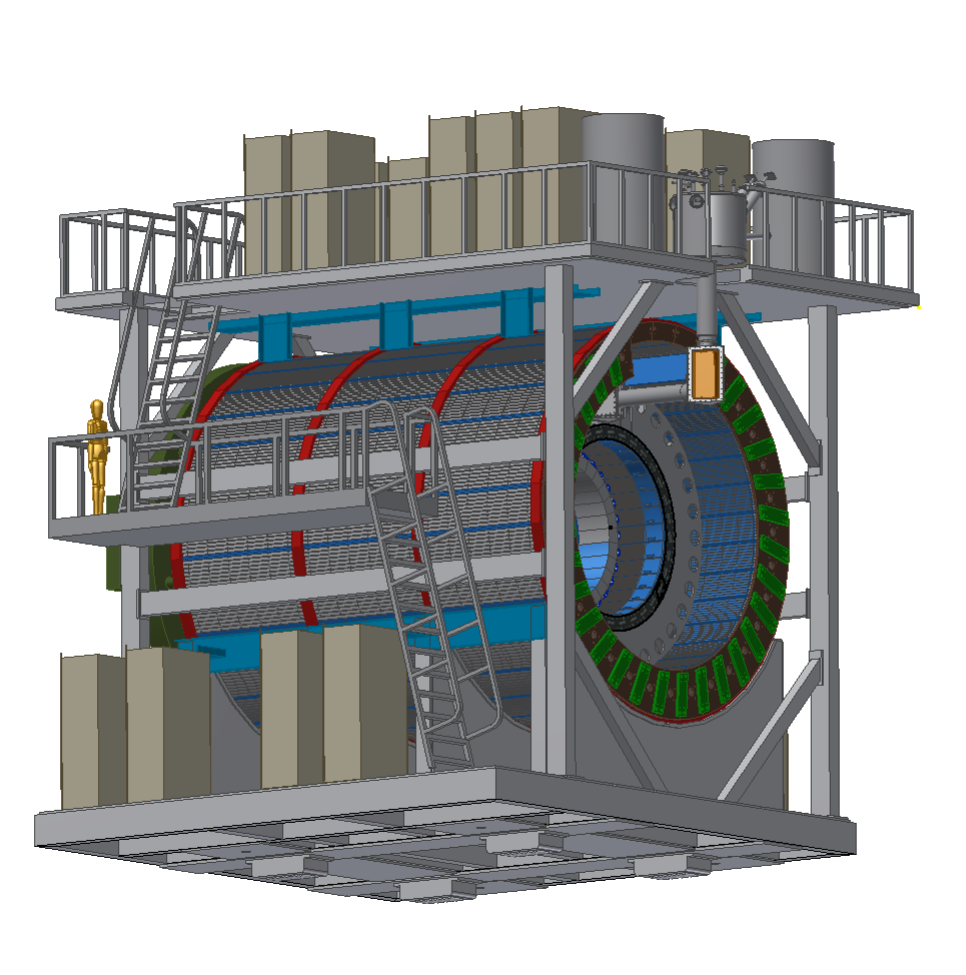
HCal Electronics Mounting



Close Up View of HCal/EMCal



Current Conceptual Design



- Mechanical Design of EMCal, HCal and support structures is progressing.
- Design includes
  - Locations of electronics racks
  - On-Detector electronics mounting
  - Cable routing- signal and power
- More details in J. Haggerty's talk

Electronics Team

- BNL Physics:
  - Eric Mannel: L2 Manager
  - Sean Stoll: Optical Sensors
  - Steve Boose: Frontend Architecture and Design
  - Sal Polizzo: Frontend Layout and Technical Support
  - Martin Purschke: DAQ
  - Ed Desmond: DAQ
  - Frank Toldo: Technical Support
  - Rich Ruggiero: Mechanical Design
  - Chris Pontieri: Mechanical Design
- Columbia University/Nevis Labs:
  - Cheng-Yi Chi: Backend Architecture and Design
  - Bill Sippach: Design Engineer and Layout
  - Nancy Bishop: Technical Support

Design Philosophy

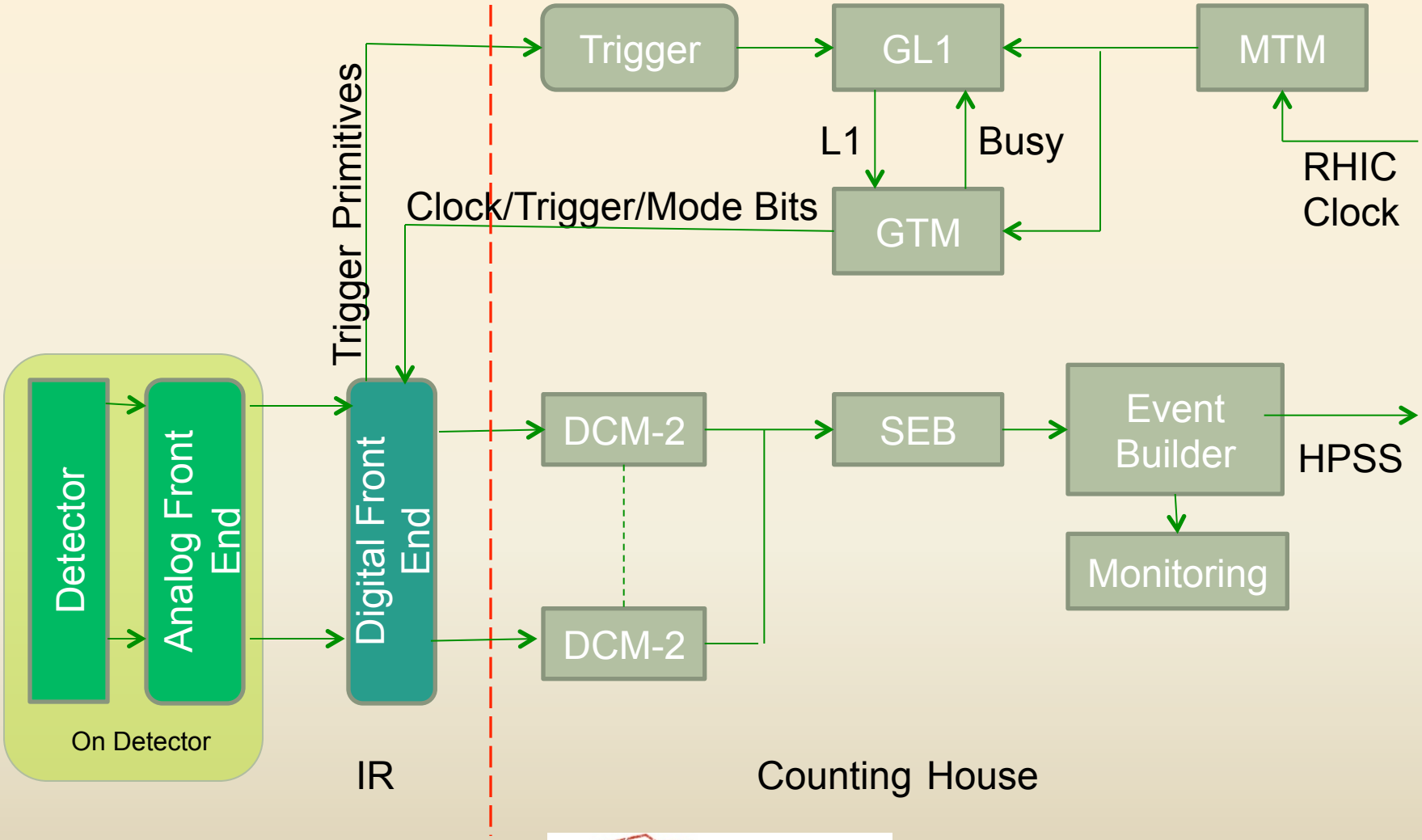
- Digitize all calorimeter waveforms for subsequent analysis.
- Take advantage of PHENIX expertise
- In order to reduce risk & Cost:
  - No custom ASICs -> off the self components
  - Same optical sensor for EMCal and HCal
  - Similar readout for both EMCal and HCal
  - Same digitizers for both systems
  - Common biasing and low voltage systems
- Minimize On-Detector power/heat load
- Use PHENIX DAQ
  - DCM-II
  - Event Builder
  - Data Logging
  - Monitoring

Design Overview

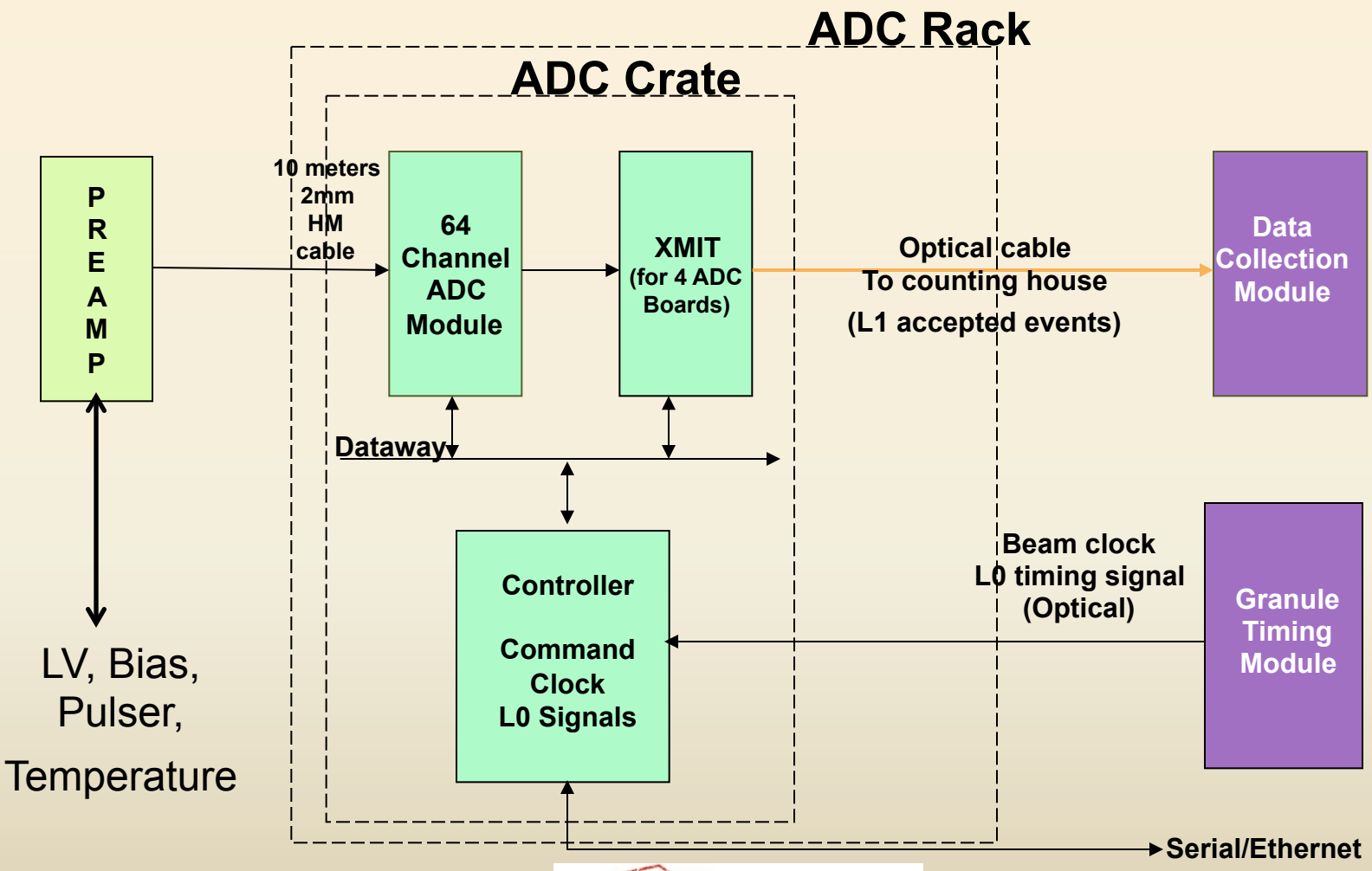
- SiPM preferred optical sensor:
  - Large gain, ~10^5
  - Dynamic range: ~10^4
  - Immune to magnetic fields
- Local amplification and gain stabilization: On Detector
- 2mm Hard Metric cable used to transmit analog signals to digitizers; cross talk measured to 10^{-3} level.
- Digitization nearby (off detector) using 14 bit ADCs at 65 MHz.
- Digitizer boards produce trigger primitives for trigger generation.
- Details in coming talks

- Potential concerns:
  - Temperature dependence
  - Neutron Damage

sPHENIX DAQ Overview

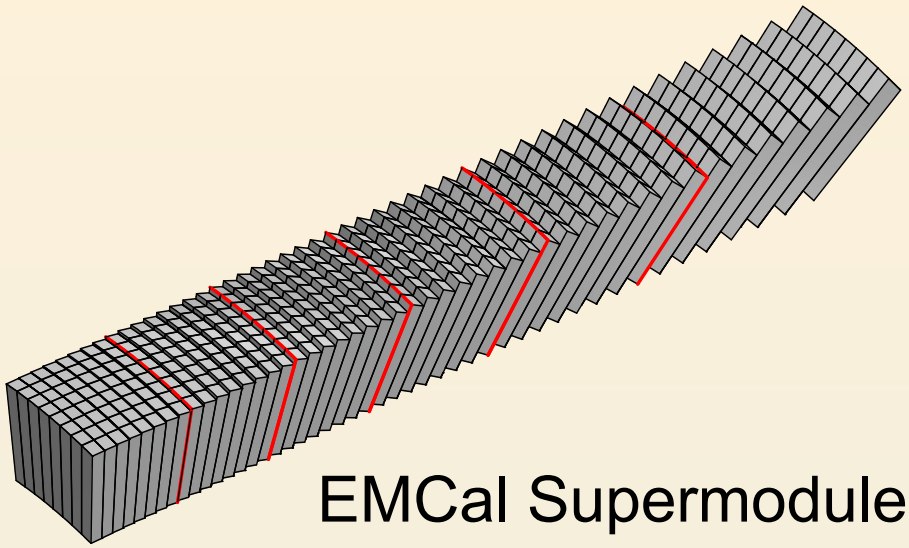


sPHENIX HCal/EMCal Readout



Segregation of EMCal Channels

- EMCal
  - Channel Count;
    - 96 towers in η (z)
    - 256 towers in ϕ
    - Total towers: 24576
    - 4 SiPMs per tower, total SiPMs: 98304
    - Total channels: 24576
  - Readout both ends (1/2 of η (z) coverage)
    - 48 channels per ϕ slice per half detector
    - Group 8 ϕ slices per readout sector, 348 channels
    - 48 signal cables (8 differential pairs/ cable) per sector
  - Power and control from both ends



EMCal Supermodule
8 x 48 towers

Segregation of HCal Channels

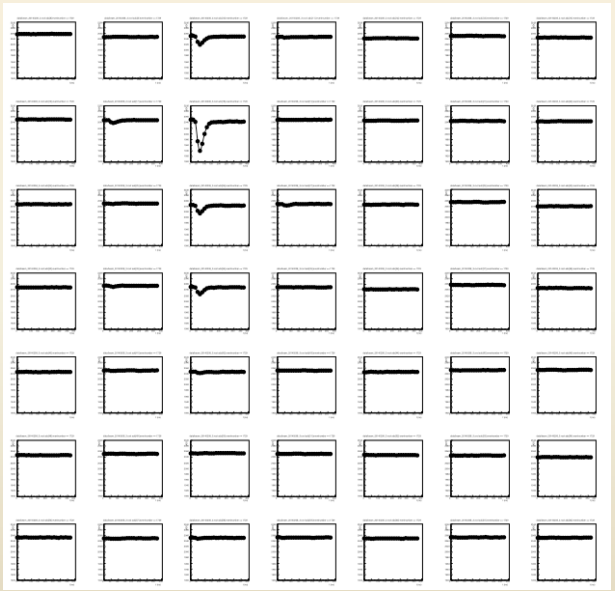
- HCal (inner and outer)
  - 2 layers, inner/outer
  - 24 towers in η (z)
  - 64 towers ϕ
  - Total towers: 3072 (Inner + Outer HCal)
  - 5 SiPMs per tower: 15360 SiPMs
  - Total Channels: 3072
- Readout both ends, (1/2 of η (z) coverage)
  - 24 channels per ϕ slice, per half detector
  - 2 ϕ slices per readout sector, 48 channels per readout sector
  - 6 signal cables per sector
- Power and control from both ends

Overall Schedule

- Three Prototype rounds
  - First 2 rounds are performance tests on the bench.
  - Preproduction prototype includes chain test:
    - Front end “on-detector” analog electronics
    - Back end “off-detector” digital electronics
    - Mounted on preproduction detectors
    - Read out using sPHENIX stand-alone DAQ
- Reviews:
  - Performance reviews of each prototype stage
  - Electrical safety review
  - Production Readiness Review
- Milestones included in WBS schedule

Current R&D Efforts

- FNAL T-1044: Feb 2014
  - Prototype EMCal/HCal modules
  - SiPM optical sensors
  - Prototype EMCal and HCal preamp/ driver circuits
  - PHENIX HBD readout electronics (12 bit ADC @ 60 MHz)
- Next generation preamp/driver circuits under development
  - Ready for testing in coming weeks
  - Tested on next generation prototypes
- First generation digitizers
  - Layout in progress
  - Testing late 2015



Issues and Concerns

- Optical Sensors (Sean Stoll/Steve Boose):
  - Radiation tolerance
  - Temperature dependency
- Cooling:
  - Minimize “On-detector” electronics
  - No liquid cooling required
  - Forced air
- Cable Routing (John Haggerty);
  - Sufficient space Will require close coordination with mechanical design
- Acessablility (John Haggerty):
  - Minimize On-Detector electronics
  - Include access plans in design where possible.

Summary

- Design is maturing but some details still need to be worked out.
  - Have a global conceptual design from sensor to data logging.
  - Based on years of PHENIX experience.
  - Optical Sensors: SiPMs.
  - Preliminary preamp/driver circuit being tested.
  - Digitization system being readied for testing.
  - PHENIX DAQ well understood
- Using same design concepts for EMCal and HCal.
  - Simplifies overall design work
  - Reduces complexity
  - Reduces risk
- Following talks will cover more of the details.

BACKUP/SUPPORT SLIDES-

Crate and Rack Requirements

- 48 Digitizer boards required for HCal
- 4 Digitizer boards per XMIT Group- 12 XMIT Boards
- 6U Crate
  - 1 Crate controller
  - 3 XMIT Groups
    - 1 XMIT Board
    - 4 Digitizer Boards
  - 16 Total modules per Crate (20 slots)
  - 4 slots reserved for trigger modules
- HCal requires 4 total crates (1 per quadrant) for digitizers
- Four additional crates required for voltage/bias distribution.
- 12 DCM-II Fibers
  - 8 DCM-II channels per module
  - 2 DCM-II modules for full HCal